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Non-traumatizing percutaneous right heart catheter

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A new catheter suitable for right heart catheterization with percutaneous technique is described. It is made out of the standard PE 160 catheter. The catheter tip does not irritate the myocardium because it has an end loop and the catheter cannot enter fine vessels. The catheter is also easily passed to the pulmonary artery without the aid of X-rays. *It has proved useful in pulmonary artery catheterizations on 73 normal subjects and 142 patients. Extrasystoles are sometimes seen but there have been no disturbing complications.*

Catheterization of the pulmonary artery has become more common in clinical practice in recent years. The introduction of flow-directed catheters (Bradley, 1964; Fife and Lee, 1965; Scheinman, Abbott, and Rapaport, 1969) has made it possible to follow for example left ventricular insufficiency after myocardial infarction (Fluck *et al.*, 1967). We became interested in these catheters to study the pressure changes in the pulmonary artery, which accompanied redistribution of pulmonary blood flow caused by respiratory manoeuvres or inhaled gases (Arborelius and Lilja, 1972; Lilja, 1972). However, we found the introduction of common flow-directed catheters to be time-consuming and difficult. Using the percutaneous technique, it was difficult to enter the veins with catheters without well-tapered ends and, furthermore, extrasystoles occurred at a disturbing rate when the straight tips passed the right ventricle.

The common PE 160 catheter[1] gives good pressure registrations and allows easy sampling of blood. For that reason we developed a catheter suitable for pulmonary artery catheterization from the standard PE 160 catheter which is easily introduced percutaneously.

Subjects and methods

The catheter has been used in 73 healthy male volunteers and in 142 patients with pulmonary or heart disease at rest, and during exercise tests in the supine or sitting position. All normal subjects had been carefully informed about the risks involved with simple right heart catheterization and consented to the investigation.

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[1] Intramedic ®, Clay Adams, New York, U.S.A.

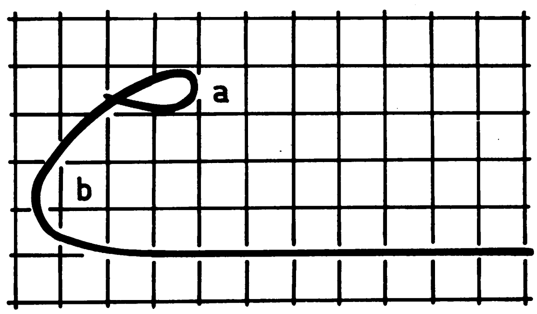

FIG. 1 *Distal end of the catheter. a = end loop ≈ 200°; b = second bow ≈ 130°. Side of squares 10 mm.*

The catheter is modelled as shown in Fig. 1. At a distance of 20 mm from the tapered end the catheter is bent 200 degrees with a radius of 4 mm (a), and 50 ± 10 mm from this loop it is bent 120 to 135 degrees in the same plane (b).

The catheter is made from a PE 160 catheter, 105 cm long, which is tapered off by stretching the catheter over a steel guide as usual. With the steel guide still inside, the catheter is then first bent about 90 degrees 20 mm from the tapered end and dipped into boiling water. Thereafter, the loop can be finished without kinking the catheter and fixed in cool water. The steel guide is now removed. It may be necessary to form the desired loop once more without the guide, reheat, and cool off before it becomes permanent. The second bow (b) is made without the steel guide, heated and fixed as described above. The tip must not be heated during the bending as this destroys the tapering.

Catheterization technique

1) With the Seldinger technique (Seldinger, 1953) the

catheter is introduced into the medial antecubital vein in one of the arms, preferably the left one. The tip of the steel guide should be about 5 cm in advance of the tip of the catheter.

2) Under fluoroscopy the catheter and steel guide are advanced to the superior vena cava. The steel guide is drawn back 20 cm and the catheter advanced about 15 cm, while the electrocardiogram is watched for extrasystoles. The position of the catheter in the pulmonary artery can now be checked by fluoroscopy after advancing the steel guide to the tip of the catheter or after removing the steel guide by filling the catheter with *x*-ray contrast. If connected to a pressure transducer, typical pulmonary artery curves will be obtained (Fig. 2). In order to ensure that the final loop can form great care must be taken not to advance the catheter so far that the tip could enter the coronary sinus before the steel guide is withdrawn. If the catheter enters the coronary sinus before the loop has formed, it may perforate the wall of the sinus.

FIG. 2 *Pressure curves obtained from the pulmonary artery in the same subject with: (a) the proximal lumen of a 9 F Cournand double lumen catheter; (b) the PE 160 catheter described in this report.*

3) The catheter may be passed without *x*-ray control if the steel guide is removed after entering the subclavian vein. By measuring on the outside of the patient it is possible to calculate how far the catheter has to be advanced from this point to reach the pulmonary artery. The position of the tip can be followed by monitoring the pressure.

4) If multiple extrasystoles appear, which is uncommon, the catheter should be withdrawn to the level of the right atrium and thereafter slowly advanced 10 to 15 cm again. Occasionally the catheter passes down the inferior caval vein, so if right ventricular or pulmonary artery pressures are not registered when an appropriate length of the catheter has been introduced, the catheter has to be drawn back to the level of the superior caval vein and advanced again.

Discussion

Polyethylene catheters have been used for several years and are easy to handle. The final loop of this catheter makes it impossible to enter the coronary sinus or any fine vessels where damage might be caused. It also distributes the pressure exerted by the catheter tip on the myocardium on a wide surface so that extrasystoles usually do not occur. Though the catheter is probably only partly flow directed, it does often pass the right ventricle at the same rate as it can be introduced into the vein. In the pulmonary artery the catheter follows the blood stream but cannot pass to a wedge position. It has never slipped back into the right ventricle when the subject moves from the table to a sitting position or during exercise tests in the sitting position.

Wedge pressures are not obtained with this catheter. However, a very good correlation has been shown to exist between the pulmonary artery end-diastolic pressure and the left atrial pressure in subjects with normal pulmonary vascular resistance, while pulmonary artery end-diastolic pressure may exceed left atrial pressure if pulmonary vascular resistance is high (Jenkins, Bradley, and Branthwaite, 1970; Kaltman *et al.*, 1966).

The wall of the catheter is not elastic and the lumen is comparatively wide, so it gives good records of the pulmonary artery pressure thus enabling reliable measurements of both systolic and diastolic pressures (Fig. 2b) to be made; these are not easy to obtain with float catheters with elastic walls and fine diameters. The wide lumen also enables easy sampling of mixed venous blood. The form of the catheter must follow the one described here as closely as possible, as it has been found that even small variations from this pattern may make it difficult to pass the right ventricle.

The catheter has not caused any complications when used as described here. Usually, the subjects do not notice when the catheter passes the right ventricle. The catheter seems to have some of the advantages of the flow-directed catheter described by Swan *et al.* (1970), but can be introduced percutaneously and is less expensive.

With the use of the new PE 160 catheter, right heart catheterization has become such an easy procedure that it is done at our laboratory for a wide range of indications and often helps to decide whether cardiac or pulmonary disease is the main cause of dyspnoea in certain patients.

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